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Dychko D. V., Dychko O. A.

STUDY OF THE DYNAMICS OF INDIVIDUAL INDICATORS OF THE FUNCTION OF THE VEGETATIVE NERVOUS AND CARDIORESPIRATORY SYSTEMS IN ADOLESCENTS AT THE AGE FROM 15 TO 17 YEARS OLD WITH SCOLIOSIS

State Higher Educational Institution «Donbas State Pedagogical University» (Sloviansk, Ukraine)

dychko.danil@gmail.com

The article is devoted to the study of changes in individual indicators of the function of the vegetative nervous and cardiorespiratory systems in adolescents at the age from 15 to 17 years old with scoliosis and their conditionally healthy peers (boys and girls) from secondary schools. The studied group includes 24 teenagers (13 boys and 11 girls) with scoliosis, the controlled group includes 30 teenagers (15 boys and 15 girls) who are relatively healthy.

The physical work capacity of adolescents is assessed by such indicators as: myocardial oxygen demand, Kerdo index, endurance coefficient, Robinson index, maximum stroke volume, minute blood volume and average arterial pressure. As a result of the study, it is established that scoliosis at the age of 15-17 years is associated with a significant activation of the sympathetic and adrenal system of the body, but only in this age group the predominance of sympathetic and adrenal influences is more typical for boys, while in younger age groups the highest indicators of activity of the sympathetic part of the vegetative nervous system is observed in girls with scoliosis. Scoliosis in adolescents at the age from 15 to 17 year old begins to be associated with detraining of the cardiovascular system, while in earlier periods of life, compensatory mechanisms allowed to testify to a sufficient level of training of the heart muscle in children.

Key words: teenagers, 15-17 years old, scoliosis, cardiorespiratory system, vegetative system.

Connection of the publication with planned research works.

The work is carried out within the framework of the thesis in accordance with the plan of the State Educational Institution "DSPU". The research is a fragment of the SWR "Study of adaptive reactions of the organism that are formed under the influence of various factors of nature and society", state registration No. 0115U003314.

Introduction.

The ability to adapt physically and socially is complex and diverse. It depends on many factors, such as physical condition, the ability to bear physical, psychological and emotional loads, the degree of training, etc. In maintaining homeostasis and its regulation, a key role is played by the interaction of the cardiovascular, nervous, muscular, respiratory and immune systems, endocrine glands, sense organs, as well as the hypothalamic-pituitary and limbic systems of the brain [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. One of the serious adaptation disorders, which leads to social defects and social insufficiency, is a disease of the musculoskeletal system (MSK).

Taking into account the peculiarities of the development of children and adolescents with scoliotic spinal deformity and the causes of this pathology, the problem of proper education arises. This is necessary to prevent possible secondary deviations in the emotional and intellectual spheres, physical development, as well as to prevent early disability [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

Violation of the spatial configuration of the spine leads to significant functional and later pathological changes in the work of the cardiovascular and respiratory systems of the body. These disorders in scoliotic spine deformation are caused not only by displacement or compression of the chest organs, but also by constant irritation of the autonomic nervous system endings,

which is clinically manifested by symptoms of autonomic imbalance [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

The aim of the study.

To study the dynamics of individual indicators of the function of the autonomic nervous and cardiorespiratory systems of adolescents with scoliosis at the age from 15 to 17 years in comparison with their peers from secondary school.

Object and research methods.

The base of the study is the Oleksiyovo-Druzhkivska comprehensive boarding school of the I-III degrees №. 13 for children with scoliosis and the comprehensive school of the Donetsk region. As part of the work, we examine adolescents at the age from 15 to 17 years with scoliosis and practically healthy boys and girls of this age group. Two groups are formed for the study, the first group includes 24 teenagers (13 boys and 11 girls) at the age from 15 to 17 years with scoliosis, the second includes 30 practically healthy peers (15 boys and 15 girls) from a secondary school.

The physical work capacity of adolescents is assessed by such indicators as: myocardial oxygen demand, Kerdo index, endurance coefficient, Robinson index, maximum stroke volume, minute blood volume and mean arterial pressure.

The statistical processing of the results is carried out based on the determination of the average values (M) of the standard error of the arithmetic mean ($\pm m$), the reliability of the data for independent samples was calculated according to the Student t-test, the difference is considered significant at $p < 0.05$.

The study is conducted in accordance with the provisions of the «Council of Europe Convention on the Protection of Human Rights and Dignity», «Ethical Principles of Medical Research Involving Humans», which are adopted at the 52nd Assembly of the World

Table – Dynamics of physical performance test results in children with visual scoliosis at the age from 15 to 17 years old

Indicators		Units of measurement	Controlled group			Studied group				
			Boys (n=15)	Girls (n=15)	P	Boys (n=13)	Girls (n=11)	P	P ₁	P ₂
Oxygen demand of the myocardium	rest	ml/min/m ²	9,58±0,52	8,57±0,26	>0,05	10,75±1,12	10,72±1,43	>0,05	>0,05	>0,05
	load	ml/min/m ²	28,87±1,34	27,60±1,73	>0,05	26,31±1,41	24,41±1,28	>0,05	>0,05	>0,05
	1 rest	ml/min/m ²	12,42±1,26	11,89±0,73	>0,05	11,62±1,43	13,18±1,47	>0,05	>0,05	>0,05
	2 rest	ml/min/m ²	13,22±1,02	12,31±0,49	>0,05	14,46±1,57	15,04±1,34	>0,05	>0,05	>0,05
Kerdo index	rest	con. units	16,22±1,40	14,15±0,80	>0,05	25,04±2,05	26,19±1,63	>0,05	<0,01	<0,01
	load	con. units	26,47±1,84	24,33±2,00	>0,05	66,35±2,32	65,09±1,92	>0,05	<0,01	<0,01
	1 rest	con. units	11,88±2,03	8,27±0,52	>0,05	39,82±3,96	38,82±3,47	>0,05	<0,01	<0,01
	2 rest	con. units	4,19±0,36	4,37±0,22	>0,05	46,46±2,58	51,73±1,88	>0,05	<0,01	<0,01
Coefficient of endurance	rest	con. units	3,11±0,27	2,86±0,28	>0,05	4,05±0,40	3,35±0,33	>0,05	>0,05	>0,05
	load	con. units	8,19±0,37	8,19±0,36	>0,05	16,31±1,87	13,27±1,21	>0,05	<0,01	<0,01
	1 rest	con. units	4,10±0,19	4,18±0,39	>0,05	5,20±0,29	5,46±0,25	>0,05	<0,01	<0,05
	2 rest	con. units	4,31±0,35	4,01±0,34	>0,05	7,05±0,53	7,26±0,45	>0,05	<0,01	<0,01
Robinson index	rest	con. units	87,03±3,77	81,60±2,67	>0,05	97,00±2,15	97,64±3,42	>0,05	<0,05	<0,01
	load	con. units	272,53±10,90	275,00±8,53	>0,05	235,38±13,37	220,36±3,24	>0,05	<0,05	<0,01
	1 rest	con. units	114,00±5,87	109,20±3,81	>0,05	104,85±2,17	118,09±1,54	<0,01	>0,05	<0,05
	2 rest	con. units	121,87±3,61	111,60±3,95	>0,05	126,23±2,25	141,36±2,81	<0,01	>0,05	<0,01
Maximum stroke volume of blood	rest	ml/beat	53,87±3,61	52,80±3,81	>0,05	51,23±2,86	60,45±3,32	<0,05	>0,05	>0,05
	load	ml/beat	46,40±2,32	46,80±2,00	>0,05	22,38±1,80	34,91±2,28	<0,01	<0,01	<0,01
	1 rest	ml/beat	48,12±2,27	47,60±2,69	>0,05	44,08±2,39	49,27±2,53	>0,05	>0,05	>0,05
	2 rest	ml/beat	48,79±2,88	49,20±2,11	>0,05	40,08±1,78	45,64±2,76	>0,05	<0,05	>0,05
Minute volume of blood circulation	rest	l/min	3,51±0,17	1,92±0,32	<0,01	2,52±0,23	2,58±0,26	>0,05	<0,01	>0,05
	load	l/min	6,76±0,38	6,48±0,19	>0,05	5,22±0,48	4,81±0,16	>0,05	<0,05	<0,01
	1 rest	l/min	3,70±0,27	3,33±0,48	>0,05	2,56±0,19	3,21±0,43	>0,05	<0,01	>0,05
	2 rest	l/min	3,83±0,25	3,53±0,24	>0,05	3,59±0,18	3,60±0,18	>0,05	>0,05	>0,05
Average blood pressure	rest	mm Hg	92,87±2,83	91,47±3,97	>0,05	82,08±4,22	80,64±3,12	>0,05	>0,05	<0,05
	load	mm Hg	145,13±2,68	132,73±2,12	<0,01	82,08±4,03	82,36±4,33	>0,05	<0,01	<0,01
	1 rest	mm Hg	104,93±2,21	102,67±3,07	>0,05	80,54±3,72	79,44±4,79	>0,05	<0,01	<0,01
	2 rest	mm Hg	106,33±1,56	101,27±4,35	>0,05	78,08±4,70	77,55±3,69	>0,05	<0,01	<0,01

Notes: P is a reliable difference between practically healthy boys and girls with scoliosis; P¹ is a reliable difference between practically healthy boys and boys with scoliosis; P² is a reliable difference between practically healthy girls and girls with scoliosis.

Medical Association, «General Declaration on Bioethics and Human Rights», approved by the resolution of the UNESCO General Conference, the principles of the Helsinki Declaration and normative requirements of Ukraine.

Before the start of the study, the parents of all children give their written consent to conduct observations and examinations of children using the obtained data in our work.

Research results and their discussion.

The analysis of dynamics based on the physical work capacity test in adolescents at the age from 15 to 17 years shows that the myocardial oxygen demand both at rest and during exercise, as well as during the first and second rest, is the same among practically healthy children and boys and girls with scoliosis (**table**).

During physical activity, myocardial oxygen demand increases sharply and equally in girls and boys at the age from 15 to 17 years in both the controlled and studied groups, and no significant gender differences are observed in the control group ($p>0.05$).

There is no gender difference in Kerdo's index both in the group of practically healthy teenagers at the age from 15 to 17 and in teenagers with scoliosis of the same age. However, when comparing studied groups, the several-fold excess of the Kerdo index in the group of children with scoliosis ($p<0.05$) immediately draws attention, and this pattern is typical for girls (26.19 ± 1.63

vs. 14.15 ± 0.80), as well as for boys (25.04 ± 2.05 vs. 16.22 ± 1.40 ; $p<0.05$). The discovered fact indicates the preservation of activation of the sympathetic nervous system in adolescents, which occurred in patients with scoliosis in the past.

The same tendency in the distribution of the Kerdo index remains for the load: a significant excess of the index in the group of girls and boys at the age from 15 to 17 years with scoliosis compared to the control group.

The revealed regularity is preserved both during the first and during the second rest.

Determining the degree of training of the cardiovascular system based on the calculation of the endurance coefficient make it possible to establish that the corresponding coefficient does not differ statistically significantly among the studied groups at rest ($p>0.05$). On the other hand, during loading in the group of adolescents with scoliosis, the index (16.31 ± 1.87 in boys and 13.27 ± 1.21 in girls) statistically significantly exceeds the corresponding values in the controlled group, as among girls (8.19 ± 0.36), and among boys (8.19 ± 0.37). The same regularity is observed during the first and second rest.

The analysis of the systolic work of the heart according to the Robinson index shows that at rest the highest indices are found in adolescents with scoliosis (97.00 ± 2.15 and 97.64 ± 3.42 , respectively), while at an earlier age significant levels of the index are the characteristic of practically healthy children. This may indicate

both the exhaustion of compensatory mechanisms and the progression of the underlying disease, which reaches its maximum development precisely in this age period.

The adolescents of the controlled group demonstrate a better functional capability of the cardiovascular system compared to children at age from 15 to 17 years (the average values of the index in both boys and girls of the controlled group do not exceed the mark of 87).

During physical activity, the Robinson index increase, and the indicator is statistically significantly higher in the controlled group in both adolescent girls (275.00 ± 8.53) and boys (272.53 ± 10.90). The same regularity is found both during the first and during the second rest.

The attention is drawn to the fact that during rest, the Robinson index gradually decreases, but it remains the highest in girls with scoliosis (141.36 ± 2.81).

The highest maximum stroke volume of blood at rest is found in adolescent girls with scoliosis (60.45 ± 3.32). Moreover, this indicator statistically significantly exceeds both the corresponding value in boys with scoliosis (51.23 ± 2.86) and the stroke volume of practically healthy boys (53.87 ± 3.61) and girls (52.80 ± 3.81). During exercise, there is a decrease in the maximum stroke volume of blood in the group of adolescents with scoliosis, as well as in the control group, however, the lowest values are recorded in the studied group among boys (22.38 ± 1.80). Boys with scoliosis have the lowest values of maximum stroke volume both during exercise and during the first and second rest periods (44.08 ± 2.39 and 40.08 ± 1.78 , respectively).

Physical activity leads to an increase in minute blood volume both in practically healthy children and in chil-

dren of this age group with scoliosis, while the lowest indicators are observed in girls with scoliosis (2.58 ± 0.26), and the highest – in practically healthy boys (3.51 ± 0.17).

The average blood pressure at rest is not statistically significantly different in girls and boys of the controlled group (91.47 ± 3.97 and 92.87 ± 2.83 , respectively), but it is statistically significantly lower in the group of adolescents with scoliosis. As in childhood, the lowest average blood pressure is found in adolescent girls with scoliosis, and this indicator is statistically significantly different from the corresponding value of both practically healthy girls of the same age group and boys with scoliosis ($p < 0.05$). The same regularity is observed both during physical activity and during the first and second rest.

Conclusions.

At the age from 15 to 17, the same patterns of violations of the cardiorespiratory and autonomic systems in scoliosis persist as at an earlier age. Scoliotic disease in adolescents at the age from 15 to 17 year old begins to be associated with detraining of the cardiovascular system, while in earlier periods life, compensatory mechanisms allow to testify about the sufficient level of training of the heart muscle in children, it is also determined that at the age from 15 to 17 years, according to some parameters, the training of the cardiovascular system in boys with scoliosis decreases.

Prospects for further research.

The results of the research obtained in the scientific work encourage us to the stage of the next research, aim at studying the level of adaptational tension of adolescents with scoliosis.

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ВИВЧИТИ ДИНАМІКУ ОКРЕМИХ ПОКАЗНИКІВ ФУНКЦІЇ ВЕГЕТАТИВНОЇ НЕРВОВОЇ ТА КАРДІОРЕСПІРАТОРНОЇ СИСТЕМ ПІДЛІТКІВ ВІКОМ 15-17 РОКІВ ХВОРИХ НА СКОЛІОЗ

Дичко Д. В., Дичко О. А.

Резюме. Мета нашого дослідження полягала у вивченні динаміки окремих показників функції вегетативної нервової та кардіореспіраторної систем підлітків зі сколіозом віком 15-17 років в порівнянні з їх однолітками із загальноосвітньої школи.

Об'єкт і методи дослідження. Базою дослідження виступила Олексійово-Дружківська загальноосвітня санаторна школа інтернат I-III ступенів № 13 для дітей зі сколіозом та загальноосвітня школа Донецької об-

ласті. В рамках роботи нами були обстежені підлітки 15-17 років хворі на сколіоз та практично здорові хлопчики та дівчатка цієї вікової групи. Для дослідження було сформовано дві групи, до першої групи увійшли 24 підлітка (13 хлопчиків та 11 дівчаток) віком 15-17 років зі сколіозом, до другої увійшли 30 практично здорових однолітків (15 хлопчиків та дівчаток) загальноосвітньої школи.

Фізичну працездатність підлітків оцінювали за такими показниками, як от: потреба міокарду в кисні, індекс Кердо, коефіцієнт витривалості, індекс Робінсона, максимальний ударний об'єм крові, хвилинний об'єм крові та середній артеріальний тиск.

Дослідження проводилося відповідно до положень «Конвенції Ради Європи про захист прав та гідності людини», «Етичних принципів медичних досліджень за участю людей», які були ухвалені на 52-й Асамблеї Всесвітньої медичної асоціації, «Загальної декларації про біоетику та права людини», затвердженою резолюцією Генеральної конференції ЮНЕСКО, принципів Гельсінської декларації та нормативних вимог України.

Результати дослідження та їх обговорення. При навантаженні потреба міокарду в кисні різко і однаково зростала як у дівчат, так і хлопчиків як контрольної, так і дослідної групи, у контрольної групи без суттєвої гендерної різниці.

Визначення ступеню тренуваності серцево-судинної системи на підставі вирахування коефіцієнту витривалості дозволило встановити, що відповідний коефіцієнт статистично значимо не відрізнявся серед груп дослідження в стані спокою.

Аналіз систолічної роботи серця за індексом Робінсона засвідчив, що у стані спокою найвищі індекси виявлені у підлітків зі сколіозом, в той час як в більш ранньому віці вагомі рівні індексу були притаманними практично здоровим дітям. Це може свідчити як про виснаженість компенсаторних механізмів, так і про прогресування основного захворювання, котре сягає свого максимального розвитку саме в цей віковий період. Підлітки контрольної групи демонстрували кращу функціональну можливість серцево-судинної системи порівняно з дітьми віком 15-17 років.

Найвищий максимальний ударний об'єм крові в спокої виявлений у дівчат-підлітків зі сколіозом. Причому даний показник статистично значимо перевищував як відповідне значення у хлопчиків зі сколіозом, так й ударний об'єм крові у практично здорових хлопчиків і дівчат.

Фізичне навантаження призводило до зростання хвилинного об'єму крові як у практично здорових підлітків, так й у підлітків зі сколіозом, при цьому найнижчі показники спостерігалися у дівчат зі сколіозом, а найвищий – у практично здорових хлопців. Середній артеріальний тиск у спокою статистично значимо не відрізнявся у дівчат і хлопців контрольної групи, проте він виявився статистично значимо нижчим в групі підлітків зі сколіозом.

Висновки. У віці 15-17 років зберігаються ті ж закономірності порушень кардіореспіраторної і вегетативної систем при сколіозі, що й в більш ранньому віці, сколіотична хвороба у підлітків 15-17 років починає асоціювати із детренованістю серцево-судинної системи, в той час як в більш ранні періоди життя компенсаторні механізми дозволяли свідчити про достатній рівень тренуваності серцевого м'яза у дітей, також визначили, що у віці 15-17 років за деякими параметрами проходить зниження тренуваності серцево-судинної системи у хлопчиків зі сколіозом.

Перспективи подальших досліджень. Результати дослідження які отримані в роботі спонукають нас до етапу наступного дослідження, спрямованих на вивчення рівня адаптаційного напруження підлітків зі сколіозом.

Ключові слова: підлітки, 15-17 років, сколіоз, кардіореспіраторна система, вегетативна система.

STUDY OF THE DYNAMICS OF INDIVIDUAL INDICATORS OF THE FUNCTION OF THE VEGETATIVE NERVOUS AND CARDIORESPIRATORY SYSTEMS IN ADOLESCENTS AT THE AGE FROM 15 TO 17 YEARS OLD WITH SCOLIOSIS

Dychko D. V., Dychko O. A.

Abstract. The purpose of our research work is to study the dynamics of individual indicators of the function of the autonomic nervous and cardiorespiratory systems of adolescents with scoliosis at the age from 15 to 17 years in comparison with their peers from secondary school.

Object and research methods. The base of the study is the Oleksiyovo-Druzhkivska comprehensive boarding school of the I-III degrees №. 13 for children with scoliosis and the comprehensive school of the Donetsk region. As part of the work, we examined adolescents at the age from 15 to 17 years with scoliosis and practically healthy boys and girls of this age group. Two groups are formed for the study, the first group includes 24 teenagers (13 boys and 11 girls) at the age from 15 to 17 years with scoliosis, the second includes 30 practically healthy peers (15 boys and girls) from a secondary school.

The physical work capacity of adolescents is assessed by such indicators as: myocardial oxygen demand, Kerdo index, endurance coefficient, Robinson index, maximum stroke volume, minute blood volume and mean arterial pressure.

The study is conducted in accordance with the provisions of the «Council of Europe Convention on the Protection of Human Rights and Dignity», «Ethical Principles of Medical Research Involving Humans», which are adopted at the 52nd Assembly of the World Medical Association, «General Declaration on Bioethics and Human Rights», approved by the resolution of the UNESCO General Conference, the principles of the Helsinki Declaration and normative requirements of Ukraine.

Research results and their discussion. During physical activity, myocardial oxygen demand increases sharply and equally in both girls and boys of both the controlled and studied groups, with no significant gender difference in the controlled group.

Determining the degree of training of the cardiovascular system based on the calculation of the endurance coefficient makes it possible to establish that the corresponding coefficient does not differ statistically significantly among the research groups at rest.

The analysis of the systolic work of the heart according to the Robinson index shows that at rest the highest indices are found in adolescents with scoliosis, while at an earlier age significant levels of the index are characteristic of practically healthy children. This may indicate both the exhaustion of compensatory mechanisms and the progression of the underlying disease, which reaches its maximum development precisely in this age period. Teenagers of the controlled group demonstrate a better functional capacity of the cardiovascular system compared to children at the aged from 15 to 17 years.

The highest maximum stroke volume at rest is found in adolescent girls with scoliosis. Moreover, this indicator statistically significantly exceeds both the corresponding value in boys with scoliosis and the stroke volume of blood in practically healthy boys and girls.

Physical activity leads to an increase in minute blood volume in both practically healthy adolescents and adolescents with scoliosis, while the lowest values are observed in girls with scoliosis, and the highest in practically healthy boys. Average blood pressure at rest is not statistically significantly different in girls and boys of the controlled group, but it is statistically significantly lower in the group of adolescents with scoliosis.

Conclusions. At the age from 15 to 17, the same patterns of violations of the cardiorespiratory and autonomic systems in scoliosis persist as at an earlier age. Scoliotic disease in adolescents at the age from 15 to 17 year old begins to be associated with detraining of the cardiovascular system, while in earlier periods life, compensatory mechanisms allow to testify about the sufficient level of training of the heart muscle in children, it is also determined that at the age from 15 to 17 years, according to some parameters, the training of the cardiovascular system in boys with scoliosis decreases.

Prospects for further research. The results of the research obtained in the scientific work encourage us to the stage of the next research, aim at studying the level of alaptational tension of adolescents with scoliosis.

Key words: teenagers, 15-17 years old, scoliosis, cardiorespiratory system, vegetative system.

ORCID and contributionship:

Dychko D. V.: <https://orcid.org/0000-0003-0905-8228> ^{ABDF}

Dychko O. A.: <https://orcid.org/0000-0002-5300-6591> ^{ACDE}

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Corresponding author

Dychko Danil Vladyslavovych

State higher educational institution «Donbas State Pedagogical University»

Ukraine, 84100, Sloviansk, 48a Vchytel's'ka str.

Tel.: +380669418001

E-mail: dychko.danil@gmail.com

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